



EPA's Radionuclides Rule Web Cast

Written Transcript

August 4, 2004

Margaret: Welcome, ladies and gentlemen, to today's Radionuclides Rule Seminar hosted by the EPA's Office of Groundwater and Drinking Water (OGWDW). Before we begin today's seminar, I would like to review a few housekeeping items. First of all, if you haven't clicked on the "Join Now" button located in the upper right hand corner of the page, please do so now. This will launch today's Web cast. If you need assistance with the audio or web portion of today's event, please contact Customer Care by pressing *0 on your telephone keypad. You may also dial 1-800-290-5900.

We would like to acquaint you with some of the ways you can participate. As you look at your screen, you will notice a small text box in the lower right hand side labeled "Ask a Question." You may ask a question throughout the presentation by clicking on the "Ask Question" button, typing your question and clicking "Ask." Your question will be addressed during today's presentation. Also, by pressing Control H on your keyboard, this will allow you to expand the image to full screen; Control H will also bring you back to the Live Meeting console features. Again, should you need help at any time during this seminar, press *0 for an operator. I'd like to introduce Andrea Matzke from the EPA's Office of Groundwater and Drinking Water Protection Branch, now. Andrea, take it away.

Andrea: OK. Thanks, Margaret. I'm Andrea Matzke and I work in the Office of Groundwater and Drinking Water here at EPA's Drinking Water Protection Program and I work in Radionuclides and Arsenic Implementation. So, I'd like to welcome everyone to the second radionuclide Web cast that we've had and today we're going to be focusing on radionuclide treatment technologies as well as disposal of residuals. And I know a lot of you are interested in this topic and just while I'm bringing this up, we have a radionuclides residuals document that we have been working on in the past few months or so and we did send it out for review today and we're expecting comments by the end of this month. And so once we get those comments back, we can make some revisions and, hopefully, get this out by fall to everyone.

We do have a lot to pack in today, actually, we only have a couple of hours for this topic, so what we're going to do is we're saving most of the questions until the very end. We'll have 15 minutes at the end for questions and answers and we'll also address one question after each presentation. Each presenter will be able to take one question with some of those questions coming from email, as you did last time, and some of the questions coming from questions that were sent into us ahead of time. We really appreciate those folks who were able to send questions into us ahead of time. So, with that, we're actually going to skip a speaker and go straight on to Rajiv Khera and he will be talking about the SPARRC model. Rajiv works in the Office of Groundwater and Drinking Water with myself. So, Rajiv, if you are ready?

Rajiv: Thank you, Andrea, I'm ready. Hi, everyone. My name is Rajiv Khara. The topic of my presentation is SPARRC, which actually stands for Software Program to Ascertain Radionuclide Residual Concentration. For this model, I'd like to acknowledge SAIC for its support. Next, Suzanne.

I'll cover the following topics during my presentation today. First of all, I'll provide a brief background on this model, state the model's objective, and lay out a case for its usefulness. Then, I'll present the overall design approach and the main features of the tool. Next, I'll briefly discuss the technologies covered in the model and will summarize SPARRC features. Finally, I'll do a brief demonstration of the tools softening module. Just as a reminder, I have only ten minutes for this presentation, so if you have any questions, please email them to me or to Andrea and I'll respond to them ASAP. Next.

So, what is SPARRC. It's a mass balance model designed to predict estimates of concentration of uranium and radium in treated water. Now, its level of precision is for pre-design decision making that systems can evaluate various treatment technologies from the waste perspective. These key features in the model were prompted by the recommendations of a 1992 Science Advisory Board Panel. So, then next.

The current version, which is about to be sent for external peer review, is a stand-alone application program using Visual Basic that models radionuclide mass balances for six treatment technologies. Now this application, this software can be used on any computer as long as you have a Window Operating System with Windows 2000 or higher version. The treatment technologies modeled in this model are conventional filtration for uranium removal, lime softening for both radium and uranium, and ion exchange for uranium and ion exchange for radium. There is reverse osmosis for uranium and radium and activated alumina for uranium and, finally, filtration for radium. Next slide, Suzanne.

So, what are its capabilities? SPARRC is designed as a predictive and decision making tool for utility operators and for regional and state regulators. In particular, SPARRC can provide information to make comparisons among technologies by raising quantity and contaminant concentrations, and radionuclides removal efficiency. This capability will also help identify the most effective way to treat source water and address waste disposal needs. Now because of SPARRC, the user can manipulate a variety of operating parameters. Another capability of the model is providing information for treatment optimization and waste treatment and disposal planning. Next slide.

For our next steps on this project, we are initiating an external peer review of the model. Also, I would like to take this opportunity to request that you review this model and of course we will always welcome your comments as well as the field data which will help us improve the precision and accuracy of the model. Now the model is available at this website: npdspermits.com/sparrc and for your convenience you can submit the field data and your comments on the same website. Next, I am ready for the demonstration.

Now I would like to demonstrate SPARRC. But before I get started I would like you to please press control key and please press H key for a full screen display of the model. For the

first time users you may want to start from the middle window and this window will take you through a step by step description, it will give you step by step description of the model. Now at the top you can see individual modules for six treatment technologies that are modeled in SPARRC. In the interest of time I will focus only on the demonstration of the lime softening module.

Now the input variables as you see them on the screen are on the left side of the screen, the 1/3 of the screen on the left inside. To input numbers you need to either click or type. To display the description for each input variable just put the mouse arrow over the input variable and it will change the color, change the color to red and a guidance document statement will pop up which contains the boundary conditions associated with this variable and the information on its units.

The output which has a sort of gray blue background is on the rest 2/3 of the screen. The top portion shows chemical dose requirements, and treated water concentrations of uranium, radium, and hard methylclenatie in the treated water. In the lower portion, the model predicts concentration of radium and uranium in individualized screens, such as backwash and sludge, as well as in the total waste screen when these waste screens are combined. At the very bottom of the screen there are buttons to help user understand the lime softening process and modeling steps and the method by which they can deliver a port and set up their printer.

Now the input variables going back on the input side, the input variables which are preceded with a red dot, so then if you want to go on alkalinity for example, indicate to the corresponding input variable like in this case alkalinity or pH is an important determinant to the model output. When you click on it, the corresponding information links to other relevant information which is displayed. Now going back to the input section, the SPARRC catches the variables in the lime softening process and accounts for all water parameters such as pH, alkalinity, carbonate hardness, magnesium hardness; it also accounts for process variables such as design and average flow, treated water carbonate, desired treated water carbonate and magnesium hardness; and variables related to chemicals such as type of lime, quake or slate lime, polymer dose; and finally it also captures backwash process variables, such as backwash loading (?), backwash time and backwash interval.

Now on the output side some of the output variables are preceded with a yellow dot. Clicking on the yellow dot links you to information outlining how SPARRC estimates the contaminate removals and provides references for the methodology, the logic used in this model. Now some output variables are preceded with a green dot, for example on backwash, so then you may want to go on the backwash if you click on that, this will show the key math balances equation for the selected topic.

So now the next question is how SPARRC mimics lime softening. Now without going into the details of lime softening process, basically, based on alkalinity and pH the software calculates the CO₂ level, you may want to move on the right so then on the treated water side at the bottom, yes, it calculates the CO₂ level and from there the amount of lime needed to precipitate calcium hardness. So, which you can see under the PO lime dose. So then where you have the required chemical dose, it also calculates lime and soda ash doses needed to precipitate

magnesium hardness. Now the basic premise is that in reality treatment plants do not soften the water to the point of solubility limit and generally would prefer to either bypass some of the flow or use a lime dose that will precipitate hardness to a level that can be as high as 130ppm. Now it captures the complex relationship between pH, lime dose, soda ash dose, and magnesium present to estimate the amount of radium and uranium removed. This is based on our standard Caldwell-Lawrence diagrams, rest assured we have not invented it.

So, as a quick demonstration, so then if you show a situation when the alkalinity is less than the total hardness, which is the case here and you have non-carbonate hardness here represented as magnesium hardness greater than 20 mg. So if you increase that to 20.1 you see that the model triggers a need for soda ash and excess lime. Now in the case when the alkalinity is equal to total hardness, it only triggers need for excess lime and similarly for uranium removal it is well established that the optimum level of magnesium hardness is desired for its effective removal and this model captures it. For example, Suzanne if you increase the, if you show the uranium removal now on the right hand side, show the uranium removal on the right hand side in the treated water, now go back and increase the magnesium hardness, now you can see the uranium removal under this scenario co-precipitates with the magnesium hydroxide. So at pH's greater than 10.8 in the treated water and magnesium carbonate greater than 20 mg per liter uranium removal is expected to be over 90%.

Now, I'm done with the demonstration and I just want to raise a question here and I'm sure that the question that you might have is how accurate are the model predictions. I believe we have done a good job in mass balancing the relationship between the variables. This model is based on sound science and empirical data which we have referenced in the model. Also we have captured the important relationship between the most relevant raw water and operation variables and the final output, such as how alkalinity and pH affects our radium removal or how magnesium level in the raw water influences the uranium removal. However like with any of the models, this model also requires field data for validation and calibration and that is where we need your assistance. We believe if we have the field data then the model predictions should be within plus negative 10% of actual value. I'm done. So if you have any questions, please email them to us. Thank you.

Andrea: Thanks Rajiv, I think we might have time for one question, I don't know if we had a question that came in, I'm looking through....let's see, OK it looks like we have one, not sure if I can read the whole thing here. "Have you validated this model with a pilot study?"

Rajiv: No we have not and that's why we are requesting field data. We have not piloted any to validate this model. But we did run some field data and we had AWWA review this model extensively for us and we got very favorable comments. And based on some of the data that we had our predictions, the model predictions are pretty close to the actual numbers. But we definitely need more data; we definitely need more field data.

Andrea: Great, thanks Rajiv. If anyone else has any other questions, again we'll be posting the questions and answers from this Web cast on our website after the Web cast. There was another question that came up, "where are the question and answers from the last Web cast?" It's a good question and we're still working on those questions. They had some very

complex questions that were out there and so we are still working on those and they should be up on our website by next week. So I guess we'll go ahead and go onto our next speaker who is Kevin Keenan, and Kevin worked for the Montana Department of Environmental Quality for 26 years and is now working with the Cadmus Group for the past 5 years. He's been doing a lot of training for a number of our drinking water rules and he'll be talking about some of the disposal options for residuals, so Kevin if you're ready?

Kevin: I'm ready, thanks Andrea. We have a presentation here that's about 36 slides long and about 33 or 34 minutes to do them so we'll move through them rather quickly. This issue does not lack for complexity. It's important that water system owners and operators understand that there is a possibility and it's a real possibility that has to be watched for, that when they remove contaminants from their waste water, those contaminants may accumulate to produce a waste which is more difficult to dispose of than it might have been because of the presence of radio-nuclides of other contaminants.

This first slide of course, the title slide we just want to call your attention to the fact that treatment processes, if they are appropriately designed and operated, are going to be operating to meet drinking water standards expressed as an MCL. The bottom line here is that if the treatment processes will in fact concentrate contaminants into solid or liquid waste streams that require appropriate handling and disposal, that's what we're here to talk about today.

The options for disposal are going to be influenced by a variety of things and we've listed a few on this slide. Number 1 is the concentration of radionuclides and co-occurring contaminants in the wastewater stream. You have to think about hazardous waste, that is the definition, the defined term hazardous waste. Under federal and state laws you have to think about TENORM, the technologically enhanced naturally occurring radioactive materials that might accumulate in higher concentrations. Low-level radioactive waste, the concept of mixed waste that is radioactive waste and a hazardous waste mixed together. Need always be mindful of federal, state, and local regulations and I think for emphasis, it's important to highlight state and local regulations, because they seem to be those regulations that will be the biggest players in this kind of decision making. And then of course there's a need to be concerned with the type of residual that you're dealing with or that you may deal with, depending on the kind of treatment that you propose to use or that you are using.

Definition for waste, of course there is a definition in the law for hazardous waste, remember this is a defined term. TENORM, technologically enhanced naturally occurring radioactive material, this also is a term of art, although it's not precisely defined. Low-level radioactive waste and mixed waste we'll talk about very quickly in this presentation. Remember that hazardous waste is regulated under RCRA, the Resource Conservation and Recovery Act. The definition of solid waste is first determined for the purposes of the definition in the law and it includes sludge from water supply treatment plants among other things. And then a solid waste is a hazardous waste if its not excluded from regulation under this section that we are showing right there in the slide or if it exhibits a characteristic of toxicity, corrosivity, reactivity, or ignitability listed also in the citation that's shown. Remember hazardous waste can also be specifically listed. It's important to keep in mind that the presence of radionuclides, in and of itself, in and of themselves does not make the waste hazardous.

The concept of TENORM. This is a very broad subject but, it is regulated not specifically as TENORM, but regulated by numerous federal regulations. Remember it's defined as naturally occurring materials that are concentrated during some process and that represent a potential for harm to humans because of exposure to those concentrated amounts. It does include a variety of waste streams generated by water treatment plants, it also is often found in fertilizer plants, mining, and oil and gas production. There is a great variety and if you're interested in a little bit more on TENORM, the concept of TENORM, there is a website that the EPA maintains (www.epa.gov/radiation/tenorm/faq.htm) where there are some questions and answers.

Low-level radioactive waste is defined by the low-level radioactive waste policy act and it's kind of defined in a backwards, in a backdoor way, in other words defined in part by what it's not. Low-level waste is not a high level radioactive waste, but nuclear fuel byproduct material and then it is classified by the Nuclear Regulatory Commission as a low-level radioactive waste. It's important to know that if source or special nuclear materials are in a waste it may be a low-level nuclear waste. Radium is not a source or byproduct material, by definition, but uranium and thorium are source materials and may be subject to Nuclear Regulatory Commission licensing requirements.

If uranium or thorium (that may be source materials), make up less than 0.05% or 1/20th of 1% by weight, and the total is less than 15 pounds, then this is going to be a source material that is of unimportant quantity and will then be exempt from NRC regulations. That can be translated in terms of picocuries to, for natural uranium to 335 picocuries per gram. That definition that you see on the slide right now actually comes out of two different sections in the law. The first is the issue of an unimportant quantity and the second is a small generator which is less than 15 pounds. If uranium or thorium make up less than 0.05% and the weight is less than 15 pounds, then it won't be necessary for a person to get a license from NRC for the presence, disposal, or transfer of that material.

The issue of mixed waste is one that's come up many, many times over the past several years when we've talked about the upcoming arsenic regulations and the upcoming radionuclide regulations. The issue here is that if a waste contains both a hazardous waste, now that's under the definition in RCRA, and a source or byproduct material subject to the Atomic Energy Act, then it may be a mixed waste. But keep in mind that we just talked about an opportunity for exemption and an opportunity to be determined to be an unimportant quantity. More than 0.05%, more than 1/20th of 1% uranium or thorium by weight and totaling more than 15 pounds plus hazardous waste may make a mixed waste subject to a general license from NRC or Agreement state. Now the key here is that you have to have both. If you have the uranium or thorium in the quantities but you do not have a defined hazardous waste you're not going to have a mixed waste and vice versa. So it's important to remember that before you trigger the definition of a mixed waste, you must have both, and if either one is not there then you don't have a mixed waste and you don't have to worry about the mixed waste issues for disposal.

A quick look at a summary of the states, statutes, and regulations that we're going to be dealing with: RCRA (Resource Conservation Recovery Act) dealing with landfills and hazardous material disposal; Safe Drinking Water Act, specifically in this case, the Underground Injections

Control regs potentially for disposal of these kinds of residuals; Atomic Energy Act, Nuclear Regulatory Commission regulating radioactive materials; Clean Water Act, we're going to talk about that because of the possibility that there's a liquid waste stream that may be disposed of either by a discharge permit or to discharge to a POTW; DOT Regulations because you can't move a waste (in some cases) if it triggers a regulation of the DOT; and then the big player, state requirements. State requirements are gonna be the ones that ultimately control these issues, but don't forget there are numerous federal regulations. A point of interest is that no federal waste disposal regulation specifically mentions TENORM, and those definitions can vary among the regulations. An example of that is DOT and RCRA. RCRA defines hazardous waste and DOT uses a different definition of hazardous, it's more of a plain meaning, dangerous waste. State and local waste disposal facilities may have additional requirements and in fact they may not have any there. They will have additional requirements, they'll need to have additional requirements to be responsive to their needs.

RCRA. First of all RCRA of course, defines a solid waste and then defines hazardous waste so it will control the identification, management, and disposal of solid waste, including sludge. That means if you generate a solid waste, by definition under RCRA, including drinking water sludges and drinking water treatment plant sludges, you must determine whether the waste is hazardous. You're going to use chemical methods or you're going to use other methods, but specifically you're either going to look for a listed waste or you're going to be involved in the TCLP procedure. That's the toxicity characteristic leaching procedure to determine whether or not the waste you have will trigger the determination of hazardous. All waste then that exhibits that toxicity, corrosivity, reactivity, or ignitability or is listed specifically is going to be a hazardous waste. The requirements for its disposal will depend on the amount produced monthly and the amount of the hazardous waste stored. Remember there are several categories: large quantity, small quantity, and conditionally exempt small quantity. Those depend on weight in kilograms produced on a monthly basis and held on an annual basis. A really important issue here to remember is that with hazardous waste as defined under RCRA, your liability remains. So it is important for systems to make this determination, make it correctly, so that they can correctly dispose of the waste, if in fact they trigger these requirements.

This slide just very quickly shows that RCRA Subtitle C, which deals with hazardous waste and in fact controls low-level radioactive waste landfills. Also Subtitle D, which controls landfills in general. That's where you can find the requirements for the disposal facilities that may be able to dispose of a waste that you produce in the process of treating water.

The Clean Water Act, directives charged under NPDES, most states have a delegated program. Montana has the MPDES, Montana Pollutant Discharge Elimination System permit. It's a permit that may allow a system to discharge the liquid waste stream directly into receiving water. The other possibility is that you may be able to discharge your waste into a publicly owned treatment works (POTW). This also can be done only with the permission of the POTW and likely through a pre-treatment permit to control the content of that waste and the quality of that waste. Federal NPDES regulations don't set specific limits on radionuclides. That means that states that operate programs, if they are to authorize NPDES discharges and disposal, will have to set those limits. One of the biggest considerations may be anti-degradation in terms of radioactive material rather than specific limitations related to health. EPA regulations on use and

disposal of sewage sludge do not currently cover radioactive material, so again you're going to see states taking the burden, if they allow this kind of disposal, and describing the appropriate conditions of that waste upon disposal. The Clean Water Act states systems should always contact the NPDES program to determine whether their system needs NPDES or other permit, they should also contact the POTW to insure that the waste will be accepted. Also, understand that POTWs aren't required to accept any waste and they will have conditions for the disposal of a waste.

Safe Drinking Water Act considerations. I mentioned earlier underground injection control (UIC), and we had a small section on UICs. EPA is required to develop minimum requirements for UIC programs. There are 5 different kinds of underground injection wells and we'll have a brief presentation on that later in the program.

DOT will regulate the transfer, transportation of materials, shipping, labeling, and transport. DOT defines hazardous to include radioactive materials, and again I must remind you that this is not the same meaning as hazardous waste under RCRA. DOT does have some exemptions in their requirements for the kinds of waste that might be part of water treatment plant waste. DOT exempts certain kinds of materials provided the concentration does not exceed 10 times the activity concentration presented in table at 49 CFR 173.436. Just as an example, uranium that we talked about earlier [phone rings in] seven picocuries, radium 226 and 228 are listed at 270, that means 10 times that number can occur in a waste before DOT requires licensing. The Atomic Energy Act regulates development and use of nuclear facilities; and the creation, generation, and disposal of source, special nuclear, and by-product material. However, as we mentioned earlier, uranium and thorium although they are source materials do enjoy an exemption. They enjoy the opportunity to be determined to be unimportant quantities of waste depending on the possibility that the waste can meet the 0.05% by weight limit that was mentioned on an earlier slide.

TENORM regulations are going to be principally in place by the states. According to this slide, 13 states regulate TENORM as a general conceptual group of sources of radioactivity. Each state will be somewhat different. Many states will not have any regulations in place.

Residual types are going to be both liquid and solid. We're going to look at the different kinds of treatment processes for the kinds of waste that are either in a liquid stage or solid stage, and what kinds of disposal options might be worth looking into. Waste streams might include for the liquid phase, brines, in exchange salt, backwash water from filters, rinse water, acid neutralization, and concentrate regeneration from media. Solid waste that you might see will be spent resins, spent filter media, spent membranes or failed membranes, and sludges that might accumulate, either intentionally or unintentionally in your treatment process. This table will give you an opportunity to see what the likely or predicted kinds of waste will be. You see over at the left hand side of this table, ion exchange (IX), is going to have spent resin and media in terms of solid types of residuals, solid phase residuals. With reverse osmosis (RO) you have spent membranes and the membranes will fail or they'll foul and need to be replaced, and so on down through the column. This is a good slide to keep an eye on later on and refer to when you are looking at a particular water system and trying to decide what kinds of waste it may have. The table is similar for liquid residuals. The same list of technologies down the left hand side

indicating that for example the top one IX, there will be a brine waste. There may be a backwash and there will be a rinse water. For RO, there will be a concentrate. Of course RO concentrates the waste that it removes from the water supply and that will have to be disposed of periodically. Again take a look at that slide when you have an opportunity and use it as a reference.

Disposal options. Direct discharge, discharge to a POTW, underground injection, and landfills for solid waste. Here you have a chart that integrates the possibilities, residual waste liquid down the left hand side, liquid sludge, spent media, and spent membranes and the options disposal. This does not mean in any particular situation we know or anybody else knows that you will be able to get a permit, but it is worth examining the possibilities. You may also be able to discharge a liquid to a POTW, or you may be able to recycle, or use an underground injection well.

Other options. Don't forget that when you look at other options for treatment or handling of your waste stream they might include incineration, evaporation, or sludge dewatering. Remember any of these are going to have intermediate steps. For instance with incineration, you may dispose of some portion but you will have a residual stream in the form of air emissions. With evaporation ponds, you may have a residual waste stream in the form of sludges that accumulate in the bottom of the pond. Keep in mind that these are the options, but intermediate processing options will also involve the production of some kind of waste at some point that has to be disposed of. And then of course there is land spreading or soil mixing which is being practiced in many states for sludges in water treatment plants and waste water plants. EPA says be very careful about that, make sure that the demonstrated benefit is there and that the potential risks when you have a waste that may have radionuclides or hazardous waste that those risks are looked at and weighed against the advantages of using that kind of a disposal system.

Liquids. The Clean Water Act of course, controls the discharge of liquids, but it's important that you know whether or not you have an accessible and appropriate receiving body, in other words, if you have a surface water that's nearby, that's the first step. If it's hundreds of miles to a surface water that could accept the waste, then of course, this isn't an option. And then if you're going to discharge to a surface water, you need to have a NPDES permit. Keep in mind that federal NPDES regulations don't set specific limits on radionuclides. That's why I mentioned earlier that you're going to be dealing with states. States are going to have to be responsive to this if they are going to allow this kind of disposal. State anti-degradation policies will also be important.

Liquids discharged to a POTW. You're now stepped up from discharging directly to a receiving stream. You're now considering discharging a liquid to a POTW. Since the POTW will have to have a NPDES permit for its discharge, a system that wants to discharge into a collection system may need a local permit and a contract. Remember both the system, the water system and the POTW are going to remain responsible for making sure that anything that's introduced into their collection system doesn't interfere with the POTW treatment process, somehow contaminate the sludge, or violate the POTW's NPDES requirements. The likelihood is that if you discharge into a POTW's collection system, you will need to meet technically based local limits and we are again dealing with local or state requirements for the control of these kinds of contaminants. Keep in mind POTW's can refuse.

Solid residuals and landfills. The important determination is whether the waste is hazardous. That means you have to go through the steps that we mentioned earlier, look for it as a listed waste, look for results of toxicity characteristic leaching procedure (TCLP), and obviously, if the waste contains free liquids, you'll have to use the paint filter liquids test. You may have to conduct intermediate processing if there are free liquids because free liquids can't be discharged into a landfill. There are no federal requirements to test residuals for radionuclides and no federal regulation governing landfill disposal of water treatment plant solids or sludges containing TENORM. So, again, you're looking at a need for the states to fill in the gap here if you want to provide this as a method for disposal of these kinds of wastes.

Solid waste landfills. The municipal solid waste landfills can accept non-hazardous, solid, or TENORM from all water systems, subject to approval from that facility. Industrial solid waste landfill may also accept non-hazardous solid TENORM waste. Again, subject to landfill approval and the approval of, and compliance with, local and state requirements. Hazardous waste landfills are likely to be able to accept waste from all generator classes. Some have explicit permit conditions while others may have to request state approval before accepting the TENORM waste.

Complex radioactivity containing waste. Low-level radioactive waste landfills are going to be licensed by NRC or a state under agreement. There are a couple of them mentioned here in this slide. Barnwell, South Carolina, however, soon will not accept waste except from South Carolina, Connecticut, and New Jersey. Richland, Washington operates an LLRW landfill and accepts certain types of TENORM waste from all states. Another LLRW landfill is Envirocare in Utah. These last two slides are the decision trees for both the solid residual disposal and the liquid residual disposal. I encourage you to spend a few minutes with these slides. These are good useful slides. You start on this slide in the upper left hand corner and just follow through with what you know about the waste. When you come to a square where you don't know the answer, that's the time when you need to do further investigation or analysis to determine the answer. It will take you through from identifying the quantity and quality, to knowing what possible options you have for disposal. The next slide, of course, is the tree that deals with liquid wastes. There is crossover between these two decision trees. Again, don't try to do this in one or two minutes. Spend some time, read through these carefully. Decision trees are a nightmare unless you are willing to spend the time to work through each and every square and unless you're willing to stop at a square where you don't know the answer and accumulate the information you need about your waste stream to allow you to continue through the decision tree.

That finishes up my presentation. We did get some questions. One question says, "Will sewage treatment plants that receive waste from drinking water treatment plants have to amend their discharge permits if there are no federal or state discharge limits for uranium?" This is an excellent question and the answer is that sewage treatment plants, if they want to be responsive to these kinds of wastes, will have to determine what the most effective way is for them to control contaminants discharging from their system into the receiving water. This may mean applying additional NPDES limits at their discharge or applying technically based local limits upon the system that discharges into their collection systems. Another question came in. "If sludges must be dewatered prior to disposal, will the dewatering equipment have to be

decontaminated after each usage?” This is another good question. Obviously, the answer can’t be given without knowing the characteristics of the waste, but it’s a good question because it indicates the person that asked it is thinking about the possibilities for problems with handling the waste. Obviously, this is one thing you’re going to have consider when you look at your waste and the concentrations of your waste. State and local governments are going to have to come up with the appropriate kind of control on this to answer this kind of question in their day-to-day operation of sludge management equipment. And that finishes up for me. Thank you.

Andrea: Thank you, Kevin. Really appreciate it. I think before we go on, I just want to ask if our other speaker, Dennis Clifford, came on.

Dennis: I screwed up.

Andrea: That’s OK. We had some technical difficulties at first, so Dennis we’re going to put you at the end, OK?

Dennis: That’s fine with me, but since the talk is about treatment, then you can stick me in anywhere, the sooner the better.

Andrea: Margaret, can we stick him now. Can we load up Dennis’ treatment options?

Margaret: Sure.

Andrea: That’s great.

Margaret: All set.

Dennis: Well, OK. You see it here, Fundamentals of Radium and Uranium Removal, that’s the title of the talk. We’re removing radium 226 and 228 from water supplies. There’s also some radium 224, but this decays away rather rapidly. Mainly, we’ll be focusing on radium 226 and 228. Radium 226 is an alpha emitter, with a 1,600 year half-life, and 228 is a beta emitter with about a six year half-life. With respect to uranium, we have two isotopes that are of significant interest. That is uranium 238 which is an alpha emitter, this is the one on the top here. And uranium 234, which is also an alpha emitter and if those are present at their naturally occurring abundance, about half the radioactivity in the water will be due to uranium 238 and the other half to uranium 234. If these are present at their naturally occurring abundance, one microgram of uranium is approximately .67 picocuries.

Now, this slide just says that the chemical and physical chemical behavior of all those isotopes is essentially the same, although you can separate uranium 238 and 235 physically/chemically, for all practical purposes, the removal of isotopes 226 radium and 228 are the same. For example, 95% removal of radium 226 and there’s also 95% removal of radium 228. The same is true of uranium on the mass basis and an activity basis, the removal will be the same.

Now, this slide shows the radium and uranium speciation in ground water as a function of pH. We're looking at the middle column the predominant species. For radium, at all pH's, it's a divalent cation, whereas uranium and let's focus on pH as of interest to drinking water supplies, at 6.5 to 7.6, uranium exists as the uranyl, that UO_2 carbonate CO_3 , that's a dicarbonate complex with a 2- charge. It's a divalent anion. And above pH 7.6 uranium exists as a tricarboxylate anion, which has a 4- charge. The 2- and 4- charges are reasons why uranium is so easily removed from water by anion exchange and why the anion exchange resins are so easily regenerated. There's one note here that above pH 10.5 which has really nothing to do with water supplies, but which if you use a lime softening in high pH, you'll find that uranium exists as a positively charged uranyl hydroxide complex which then is removed by the magnesium hydroxide precipitate that exists at that pH.

So, here are the radium removal methods. Cation exchange softening is a best available technology listed in the regulation. The reaction is, this is basically a softening reaction. Two resin sites in the sodium form when they contact a radium ion and solution. The radium will go on to the resin, take two resin sites and give up two sodium ions. The predominant reaction going on there though is that the resin in the sodium form plus calcium or magnesium is going to release the sodium. The radium has a very high affinity for cation resins and so if you're removing hardness, you're also removing radium for sure.

Lime softening is the addition of lime typically to precipitate calcium carbonate and at higher pH's to precipitate magnesium hydroxide. It also removes radium.

Reverse osmosis work very well for removing radium. It's expensive. We did a good deal of research on the adsorption of radium onto manganese oxides. Rich Valentine at Iowa also did work on this. It's a very good method for removing radium at very low concentrations of manganese.

Precipitation with barium sulphate is also used. [audio cut out] Another method is adsorption of radium onto barium sulphate impregnated media and there's two kinds of media that we worked with. One is the so-called Dow complexer that had barium sulphate in cation resin, and the other is barium sulphate loaded activated alumina. In that case, the radium goes onto the barium sulphate that is fixed on the media.

Electrodialysis is a membrane process similar to RO except that in electrodialysis the ions move through the membranes rather than the water. It's also very effective and has the same issue with brine disposal as RO.

Now, for point-of-use. RO is listed as a BAT for radium removal, but cation exchange softening is quite applicable for small systems/household systems. In fact, most resins used in the state are probably in water softeners in homes. Adsorption onto manganese dioxide impregnated filters is a method that's quite effective. A small cartridge filter that's impregnated with manganese oxides will remove radium very effectively and adsorption on barium sulphate impregnated or alumina, again, this is the same as the full scale system, but done a small scale.

Here's a picture of a radium removal ion exchange system with bypass blending of the raw water. In the case of softening and radium removal, we don't have to remove radium down to zero, we can go from ten down to four picocuries per liter for example. Water would be passed through the resin, which is sodium-form strong acid cation resin and exchange radium, calcium, and magnesium for sodium. Then the hardness free water comes out here at the bottom of the column and the bypass raw water is blended with it to produce a product water that has the right hardness and radium level. The radium contaminated waste brine which is produced by sodium chloride regeneration is sent to the sanitary sewer if it's allowed.

The ion exchange resins for radium removal, one shown here, is standard strong acid cation resin with sulphate exchange groups is typically used.

Here's what's called a breakthrough curve from a softening system. This is the magnesium, the calcium, and radium as they come out of the end of the column breakthrough for ion exchange softening. So on the Y axis, we have calcium and magnesium and then on the other Y axis, we have radium and then way down later around 2000 bed volumes comes radium. So radium has an extremely high affinity and if you're removing magnesium and calcium, for sure you are removing radium. Now, in the first run, we can get 2000, 4000 bed volumes of run length, but then after salt regeneration, we find that radium breaks through with magnesium. So, basically these systems that are removing radium are water softeners. They're operated as softeners and when the hardness breaks through, that's when the radium run stops. And if that's the case, here's a little box on the bottom that says, if the feed water contains 10 picocuries per liter of radium then the resin is going to contain about 20 picocuries per gram at steady state. I mean after five regenerations you'll come to steady state and, at that point, you'll have about 20 picocuries per radium per gram. And the waste brine typically will contain about 600 picocuries per liter of salt.

Here is the process flow schematic for radium removal by adsorption onto preformed manganese oxide. We did work at the University of Houston and as I mentioned Rich Valentine in Iowa did a lot of work on this method of radium removal. Here, it shows in a typical small system where the feed water would also contain things like iron and manganese and we'd remove that using typically air, chlorine per manganese in a filterous system and then in a mixer we would add the preformed manganese oxide, which is made by reacting permanganate with manganese sulphate to produce manganese dioxide. It absorbs the radium immediately and at very low dosages of manganese and then it's filtered either on a diatomaceous or a multimedia filter or membrane filter. Alternatively, barium chloride may be added to precipitate barium sulphates. So instead of adding manganese, (which is black by the way, and this could be a problem in some systems, and a white precipitate is a little less troublesome sometimes) barium sulphate is also quite effective in this system.

Here's some work that shows some radium removal as a function of the dose of manganese dioxide. This is a Houston groundwater that we spiked with radium to bring its level up to either 25 picocuries per liter or 13 picocuries per liter and what this graph shows is this percent radium removal on the Y axis and then on the X axis the dosage of manganese dioxide measured as manganese. And you'll notice, too, here at .2 milligrams per liter of manganese, we're getting 50% removal regardless of the level of radium in the water, either 13 or 25

picocuries per liter. So this estimate said that if we need to get 50% removal, for example, water contains ten picocuries per liter and we want to reduce it to five, the residual dry manganese dioxide solid dried would completely contain 21,000 picocuries per gram. This is an enormous level, but then again, there's only 2/10 of a part per million of this material. It's very effective, but then the radium is highly concentrated on the waste.

Next slide shows the breakthrough curve for the so-called Radio-radium Selective Complexer which is a barium sulphate loaded cation resin. Just impregnate the resin with small particles of barium sulphate which is effective for absorbing the radium. In this case, the feed radium was about nine picocuries per liter and the effluent was zero until about 20,000 bed volumes and then it gradually came up to around nine at 60, 70, 80,000 bed volumes. Now, for those of you who don't know the term bed volumes. A bed volume is a volume of fluid equal to the volume of resin or media in the bed. It's sort of a dimensionless way to look at breakthrough curves. So, this material has a very high capacity for radium. In fact, that's one of the reasons I think Dow quit making it although it may still be available. They had problems disposing of the waste.

For single column operation, single column because with a breakthrough curve like this, one would normally use two columns in series and then exhaust the first one completely. But if we have a single column and ten picocuries per liter in the feed, the spent resin is going to contain about 500 picocuries per gram of resin. Dry resin.

This one shows the breakthrough curve for plain and barium sulphate loaded aluminum and on the Y axis is the ratio of the influent to the effluent activities, so 0.5 here is 50% removal and 0.8 is 80% removal or excuse, 80% remaining and 50% remaining and so forth. Now, typically then, if we have ten picocuries per liter in the feed, we'd like to get 50% in the effluent of that, that's about 5 or less, so we can have a run length approaching 40,000 bed volumes and this is an activated alumina that has been deliberately doped with barium sulphate in a method we described some years ago in an EPA report. The plain aluminum, activated alumina instead of getting 40,000 bed volumes is going to get more like one or two bed volumes, but it will work and one or two bed volumes is not bad actually just for removing a contaminant in an under the sink type unit.

Uranium removal methods, we jump onto those here and move. The best one is anion exchange; it's the best available treatment. And in this case, we have the anion resin which is shown here as resin in the chloride form. Four sites, that is four fluoride sites, contact one uranyl carbonate complex, which is a 4- [unintelligible] and uranium goes on, the carbonate complex is on and chloride comes off. This uranium carbonate complex because of its 4- character has an enormous affinity for the resin. And we can get very, very long run lengths.

Another method, as with radium, is lime softening. Lime softening works very well for uranium removal.

Enhanced coagulation, this would be coagulation with a pH adjusted to the proper means and the dosage to the proper dosage and that's coagulation with iron or aluminum, that is alum or ferric fluoride or ferric sulfate, it's considered the best available treatment. RO is a BAT also.

Activated alumina works pretty well and electrodialysis works as well as RO in membrane processes. But for point-of-use, there's, to my knowledge, no listed POU for uranium removal. Anion exchange is going to work extremely well in under the sink or a point of entry system would work very well for removing the uranyl carbonate. RO works, of course, and activated alumina works reasonably well.

This slide shows the affect of pH and coagulant on uranium removal at a dose of 25 mg per liter. On the Y axis it's the percent of uranium that's removed and on the X axis it's the pH. You see at pH 6 you can get typically almost 90+% removal using alum and ferric as iron 3. Iron 2 is not quite so good. Then, at pH 8, which is where we probably prefer to operate in this range that removals are considerably less and if we get up to pH 10, which is where uranium starts to have a positively charge hydroxide complex, we can remove it in these processes. And little box on the side here says it's for 50% removal of uranium which is at a level of 40 micrograms per liter, the dry sludge is going to contain about 800 picocuries of uranium per gram of dry iron sludge.

Now, here's lime softening. This is precipitation at high pH as contrasted with the last one which is generally lower pH, either 6 or even 10. This shows the effect of pH and of course, lime dose because as the pH increases, the lime dose increases. The effect of pH on uranium removal by lime softening and you see that on the Y axis, we have % removal. As the pH increased from 9, 10, or even 11, the removal increases rather dramatically. It's at these high pHs, especially when there's magnesium present, that this magnesium hydroxide is a surface unto which the positively charged uranium complex is removed. So you get really good removals up here at really high pHs, but you can get decent 50% removal even at pH's 9.5 and 10. If we're talking about a 90% removal of a 40 micrograms per liter feed water, the dry sludge is approximately going to contain 130 picocuries per gram of calcium carbonate.

One of the questions that was asked previous to this, I will answer it now. "Are there any resins that are better for uranium removal?" The best resins are like in the middle here, Type 1 macroporous resins. Type 1 means it's got this trimethyl group on the nitrogen exchange group and we use Ionac A-642, there's equivalent resins over here, Durolite and Amberlite resins.

This slide show the uranium removal during anion exchange. This is uranium concentration in the effluent and this is the number bed volumes and where, as I said, we were running water softeners to 300 bed volumes typically for softening. We can run, if you're just removing uranium on an anion resin, you can run at several hundred thousand bed volumes. That would be maybe a thousand times longer because it has such an enormous affinity for resin. And, in this case, the work was done in Chimney Hill, which is not too far from Houston. It's a subdivision and the water there contained about hundred micrograms per liter on the average of uranium. And, so, you say that basically there's no uranium until it gradually breaks through. Normally, we do not run these, even though we could run to several hundred thousand bed volumes, we have problems with pressure drop, particle filtration, algae growth, in fact, in we did these columns in the light. We have a sort of a rule that, not a rule really, an observation that 30,000 bed volumes is what I think Tom Sorg worked with some places out in California where 30,000 bed volumes was typical run length. I've seen that elsewhere, so if the feed water

contains about 40 parts per billion of uranium, the waste will contain about 80,000 picocuries per liter for 30,000 bed volume run length. And again these systems are regenerated with sodium chloride, the same as a water softener. This anion resin removal system is basically a water softener with anion resin in it.

This slide shows the effect of the uranium concentration and sulfate and chloride concentrations. It's kind of a complicated slide, but just let me tell you what it says. This is the run length on the Y axis and this is the uranium concentration and this curve on the top shows that it's decreasing. That as the uranium concentration increases, the run length goes from like 800,000 down to where it was in Chimney Hill, about 350,000. And now if the chloride is replaced with, this water had no sulfate in it, only 5 parts per million sulfate, but if sulfate's replaced with chloride in this water, then the run length would be much less because sulfate does, even though uranium has a high affinity for the resins, sulfate is a better competitor than chloride.

OK, now to summarize in the last three slides. Treatment methods for radium removal: ion exchange softening with sodium form resin using a strong acid cation resin, got 95% removal when it operated to hardness breakthrough and regenerated with sodium chloride. Barium sulfate precipitation can get any removal really depending on how much is added, but typically in the range of 50-95%. We add barium chloride to the feed water because that's a soluble salt and barium sulfate precipitates. Manganese dioxide adsorption. Again, getting 50-95% removal. We're using preformed manganese dioxide that's made in a date tank and pumped in the head of a filter or deep bed filter or precoat filter or a membrane filter. RO, of course, is always great for removing big ions like this, it's effective, but it's expensive.

For uranium removal, coagulation with iron and aluminum salts are going to remove 50-90% at pHs of 6 and 10. Lime softening, typically 80-100% or 99% removal. Higher pH means better removal and magnesium helps that pH so it's greater than 10.6. Anion exchange is quite good. Better than 95% removal for sure for long run lengths can be hundreds of thousands of bed volumes but we generally run between 10,000 and 50,000 bed volumes and regenerate with 2-4 molar salts, that's 12-24% salt solution. RO is, of course, effective here also.

This is the last slide, but I want to make this comment; the more effective the coagulant, or the absorbent, the higher the radioactivity in the residual. So I just wanted to summarize this and these are some estimates that could occur in typical systems. For ion exchange softening then for radium removal, we can have 600 picocuries per liter in the brine and 20 picocuries per liter per gram on the resin. For coagulation filtration with hydroxides for uranium removal, we can get enormous levels, like here's 21,000 picocuries per gram. Iron coagulation filtration for uranium removal is going to get 800 picocuries per gram. Now, these are dry grams, completely dry, I mean these are just calculated values. There are no such measured values, but these are based on calculation. Anion exchange for uranium removal is 80,000 picocuries per liter in the spent brine and based on a 30,000 bed volume run length.

So, that ends the presentation. There's one question that was asked in the preliminary material I received from the states, "Are there specific resins for uranium removal?" Yes. Macroporous, strong base resins of the type that I mentioned in here are better than others.

Someone asked, “Are there any surrogates that can be analyzed easily on-site for uranium removal?” Well, it’s really not necessary because these columns are going to run for such a long time. Uranium is the last ion to break through and so you probably don’t need a surrogate. The column may be plugging up with fines before it actually runs out of capacity for uranium. And, “Are there any demonstrations or reports available?” Yes, we have some. I can’t really give you chapter and verse now, but I can send it to Andrea or somebody at EPA and they can send it. We have a number of papers and reports on that subject. That’s it.

Andrea: Thank you very much. Let’s go on to our next presenter and that’s Robyn Delehanty. She’s from the Office of Groundwater and Drinking Water here in D.C. and will be talking about UIC and disposal of radionuclide residuals.

Robyn: Hi, everyone, I’m here with Bruce Kobelski, also from our office, whose specialty or expertise is in deep well injection. So, if there are any deep well injection questions that come in, he’ll be the one to answer those. I think as Kevin said earlier, we’re under the Safe Drinking Water Act. The Underground Injection Control (UIC) Program was required to develop minimum federal requirements for states and tribes for their own UIC programs. The purpose of our program is to protect underground sources of drinking water. To date, there are 33 states that have applied for and received primary enforcement capabilities. In addition to that, there’s 17 states where EPA runs the entire program or a portion of the program. Actually seven of those states are shared program responsibilities between states and the federal EPA. Again, as I said, our mission is to protect underground sources of drinking water which include current and future sources of drinking water. Basically we are looking at ground waters that are less than 10,000 total dissolved solids (TDSs), and that have a capacity to serve a public water system. So, these are the ground waters we are protecting.

OK. Briefly, the requirements for these wells, these wells were broken down into five classes and these classes are based on their construction, their function, and on their operating features. Class I wells are deep wells. They’re technical, they’re highly regulated and they receive hazardous waste, industrial waste and municipal waste. These wells are largely about a mile deep, and there are 500 of them nationally. Class II wells are related to oil and gas production. They’re wells that reinject brines and other waste fluids that have come up in association with oil and gas production. They’re also used for enhanced oil recovery, that is, they inject fluids to stimulate production wells and enhance the recovery of the oil from that formation. Currently, there are over 140,000 of these Class II wells. Class III wells are wells that are associated with the production of mining production, such as salt and uranium. Class IV wells are conspicuously absent because they’re banned. They were banned in 1984 because they allowed for the injection of hazardous waste into or above underground sources of drinking water and now are only allowed in conjunction with cleanup activities at RCRA, CERCLA, and state approved cleanup sites. If you don’t fit into Class I, II, III, or IV, you are in Class V. This is kind of the catchall category. These wells are largely shallow injection wells, septic systems, dry wells, though you can have wells that are also very deep, but they’re just uncommon. To give you an idea, there’s anywhere between 500,000-650,000 Class V wells.

OK. So, before you consider the UIC program, an important thing is to understand what your waste characteristics are. It’s dependent upon these as to what type of well might be

applicable for receiving your waste. So, the first thing is to determine whether it's radioactive, hazardous, or non-hazardous. And just so everyone is clear, under the UIC regulations, we are using the radioactive definitions as found in RCRA. OK. So, again, and we've talked about these before, but I've just listed these levels for you here.

Another thing to consider is that the UIC program does not regulate single family residential septic systems. They are excluded from regulation. However, at the same time, the Safe Drinking Water Act under 1431, gives the UIC program the authority to act in any situation where there is an imminent or substantial endangerment to public health based on a fluid that's being injected. So, that's a little caution for point-of-use of systems. We don't regulate single family homes, but if concentrations were high enough to cause that imminent and substantial endangerment, action could be taken.

So, if you want to consider using the UIC program, Class I would be an option keeping in mind that there are a limited number of these wells and they're deep injection wells below the lower most USDW. Some considerations, they're very stringently regulated. There are not a lot of facilities that are able to accept this offsite waste, meaning that many of these wells are constructed by facilities and are only permitted to accept waste from that facility. So, there's a limited number that can accept offsite waste. They are allowed to take slurries and solids only in limited circumstances, and that has to do with the operation of the well. They're very expensive to construct so it's unlikely that an individual public water system would be constructing one of these wells. Class II wells, again, are oil and gas related and by and large, they only accept those wastes that are generated from the production of oil and gas. I will say that there's one exception and that is when there's enhanced oil recovery – or when they're stimulating the formation to produce more oil. However, again, the fluid that they accept can impact that formation and so the owners of these wells are very cautious about the types of fluids that they will accept. So, again, it's unlikely that it could go into a Class II well. Class III are mining related, so this would not be an option. Class IV wells are banned and so they also would be not be an option. Class V wells, which are the most numerous type of injection wells, would not be an option if you have a hazardous or radioactive waste. Again, these are shallow disposal systems by and large, and they are injecting into or above drinking water resources. There's a protective standard and you cannot exceed any primary drinking water standard or otherwise adversely affect public health so there's probably limited use of this well type. If you would like more information, we have a couple websites here listed, this is Safe Drinking Water Hotline, and Suzanne Kelly in our office is the one who's taking the lead on this drinking water treatment residuals and the UIC. And let me just check for a minute and see if there's a question.

Andrea: OK. We're going to go ahead and see if we had any emails that came in. Well, it looks like we have one that came in before from one of the states. Would you like to read the question?

Robin: Sure. I'm going to hand this one over to Bruce because it's a Class I question.

Bruce: One of the questions was, "it sounds like Class I wells might be an option and how do you find out if there is a Class I well around?" I think the best answer here is there's nine of ten EPA regions that have Class I wells, so the regions would be a great source to

contact. Also your primacy states have a UIC program that they definitely know the information about where their Class I wells are located. If anything, although we have 470 something odd Class I wells, we do have a good handle as to where they're located and what wastes they may be willing to accept and what their permit conditions are. So, you can contact the states or regions for information and one thing I might point out too, on our website, the Safewater/UIC Website, there's a report that you could download on Class I wells. You just click on it and you'll be able to download it. Probably there's more than you really care to learn about Class I wells, but there is a lot of reference material in there that you may be able to pull from and find interesting.

Andrea: Great Bruce and thanks, Robyn. I think we'll just go ahead to our next speaker and that's Norm Hahn from the Department of Natural Resources in Wisconsin. So, whenever we get your presentation loaded up, I think you're ready to go Norm.

Norm: Thank you. Hello, I would like to briefly summarize our experiences in Wisconsin in removing and disposing radium in the community water system. I've broken it up by municipal and by other than municipal (OTM) and how many violations we have of each kind. Currently we have 34 combined radium, seven gross alpha only and two uranium violations. [audio problems]

Andrea: Hello Norm?

Norm: Yes.

Andrea: We can barely hear you.

Norm: Can you hear me better now?

Andrea: Yes. Is there a speaker phone next to you, Norm?

Norm: Can you hear me now.

Andrea: Yes, please proceed.

Norm: OK. Sorry about that. In Wisconsin, we currently have 34 combined radium, seven gross alpha only, and two uranium violations. On-going sampling may result in several additional violations. I've broken them down by municipal and OTMs on the slides. In the past, we've probably had about an additional 10-20 violations that have been taken care of over the past 20 years. The systems taking action, normally they're taking action with some other part because they have an iron and manganese problem, a softening, a hardness problem or they're replaced by surface water. There are other radionuclide reduction methods that are currently being used in Wisconsin. We have a number of systems that are either going to replace or blend with surface water and we have a number in the Green Bay and Milwaukee area that want to do that. There's also an issue with diversion of water over the basin divide from Lake Michigan to [audio cut out]

Can you hear me better now? OK. I apologize for any problems on our end here. A number of our water systems are facing the question of whether to continue to mine water from the deep sandstone aquifer or to try to get water in a diversion from the Lake Michigan basin. That's an ongoing political issue here in this region of the country. A number of systems will also be replacing or blending with low radium content groundwater where they have the ability to do so where they have multiple aquifers. Then the existing treatment, some of them have been in service for years, mainly for hardness removal or newly approved radium treatment methods of cation exchange softening or lime softening. I think we have 2-3 plants that are doing that and we have one [?] filtration plant that's been in existence since the 80's. We have two newly approved anion exchange for uranium removal plants here in the state. Those are smaller villages in the northern part of the state. They are disposing of their wastewater to a sanitary sewer. One of them just went online, I believe, and because it does such a good job, as Dennis was saying, of accumulating the uranium, they have to backwash, and regenerate fairly frequently.

We also have a number of systems that have either completed or are in the process of piloting some radium reduction methods here in the state and those include two types of radium selective complexers or radium selective media, the kind that accumulate radium but then you cannot regenerate it or backwash it off. That's the Down Company radium selective complexer, which is marketed by Lane Northwest in this state. Also the WRT Company, Z88 selective resin. We have several systems that are piloting and are looking at HML filtration. We also, historically and recently, have had several systems look at doing some geophysical logging of their wells to hopefully isolate hot zones where the groundwater [pause]

Excuse me, someone interrupted. Several systems that were looking at doing the geophysical logging and then putting in liners or packers or disks to hopefully zone off those highest radium proceeding formations, but that hasn't been real successful and if it is going to work, it's probably for systems that have violations of just directly over the standard. We also have one system that looked at EDR and reverse osmosis on a piloted basis. This department, the DNR and our Department of Health and Family Services, one of our sister departments, which contains the radium protection section, have worked together closely to come up with practical radionuclide waste disposal guidance. Given that the issue is not largely addressed (as previous presenter kind of showed that), we're kind of been on our own to some extent. So we've worked together to come up with practical guidance that would kind of fill in the holes. As I said before, we've been working on this since the early '80's when radium enforcement first started. We have in our tool and have put in criteria. We've looked at, because so much of our POTW sludge is land spread, we have looked at coming up with criteria for land spreading sludge, including water treatment plant lime softening sludge that contains radium and I'll talk about that more on a future slide. We have some criteria that we've updated. Kind of a guidance paper for consultants and utility people that we updated in March of this year and if anyone would like a copy, they could contact me and I'd be happy to provide them with a copy. In our state, any resins that accumulate, like the DOW's, RSC or the [?] media, because they continuously accumulate the radium, it will become a low-level radioactive waste. They are required to have a license both for the pilot and any final plants - for operating a plant and for disposal at a low-level radioactive waste site that would be out of this state.

And, one issue is that even though treatment in a number of systems is for radium removal, the fact of the matter is that the sludge at the POTW is already seeing that same approximate concentration. So, it's not like they're handling a new problem. We have got to make sure we're managing an existing problem correctly and treatment generally, unless you're removing the radium through a selective complex or something like that, you're still going to see approximate concentrations in the wastewater treatment sludge where the radium and/or uranium is coming out. What we've done in the state is we've looked in the back of our radiation protection section code, there's an Appendix E that contains the Code of Federal Regulations to see if our 20 criteria for disposal of radionuclides through a sanitary sewer to a surface water body, (i.e., a storm sewer) or directly to a surface water body, basically it allows 600 picocuries per liter of radium going into a sanitary sewer and 60 to a storm sewer or surface water body. But you can add in because most of it comes out in the brine, if that's what you're using, you can also add in the backwash water, the rinse water, and other wastewater generated by the plant so that the average over the month and over the year meets the criteria.

In our approvals, we look, going back at the last slide briefly. Every time we look at a water treatment plant for removing radium or uranium, we look at the issue of disposal, whether it's a solid or liquid and we make sure that we approve it as a part of that process and also in our approvals, we require that the media when it's spent or when it fails, be examined for radionuclide content prior to its disposal. Now, when we presented the landfill and solid waste disposal issue to our solid waste people, they weren't interested in codifying those requirements due to the work involved and because it's a roughly small part of what they believe is their total workload, so we have still have criteria for disposal of our TENORM waste to a landfill and anything that's between 50-2000 picocuries per gram by dry weight of content has to be reviewed both by us and by the radiation protection section before we approve it for disposal. Anything with a content of more than 2000 picocuries per gram has to go to a low-level radioactive waste disposal site.

I thought you might be interested in seeing, because we do so much land spreading, where does all our POTW sludge that contains the radium, where does that go? 94% is land spread. 3% is fertilizer production. 2.5% is landfilled and 0.5% is incinerated.

And this is a quick summary of our NR Tool for land spreading criteria where and this was also reviewed in addition by the radiation protection council, which is now disbanded, but at that time was a group of experts from around the state who were advisors to the radiation protection section and for the legislature. Radium 226 is considered the controlling factor due to its long half-life and because it gives off radon gas which is a concern for future uses above the landfill or a site that's being land spread, maximum 2 picocuries per gram radium 226 dry weight in the top 12 inches limit. The soil pH has to be greater than or equal to 6. There has to be some minimum organic matter content required in the soil so that when the sludge is applied, the radium doesn't quickly move off the site and at 1640 microcuries per acre, the loading has to stop and a site can be sampled to see what the radium content if the theoretical calculations are exceeded. The people in wastewater tell me that so far, no site has yet exceeded its land spreading life.

We do not allow deep well injection here in this state. We do approve it, especially for OTMs, disposal of cation exchange regeneration water containing radium to a septic system if that's the only alternative. Currently, we do not regulate for disposal of the sludge, we regulate from septic systems, it's either land spread or it's sent to a POTW, but the radionuclide content of that septic system sludge is not currently regulated. And, our Department of Health, in conjunction with us, has looked at two systems; one is a cation exchange softening plant, one was the HMO's filtration plant looking for gamma radiation outside the vessels containing the media and checking for radon gas, either when hatches are opened or when units are regenerated and the backwash regeneration water empties into the sump and some rise very quickly. There was not much gamma radiation given off above background right outside the shelves, however, radon gas was a concern either when the tanks were opened or the regeneration occurred. There should be proper ventilation and/or the operator should not be present in the room during that time. That really concludes my talk. Apologize for any technical difficulties if you could not hear me.

Andrea : I think we have time for a question, Norm, I really appreciate you giving us this presentation. It's nice getting a perspective from a state. Is there a question that came up?

Norm: I'm having trouble hearing you.

Andrea: That's OK. I'm looking to see if any questions came up during your presentation and I'm not sure if they did. I think what we'll do is if there are any questions, we'll answer them at the end. So, right now, we'll just go on to our next speaker, Loren Setlow and Loren is a geologist with EPA's Office of Radiation and Indoor Air. He is presently Chair of the Naturally Occurring Radioactive Material Subcommittee of the U.S. Government's Interagency Steering Committee on Radiation Standards (ISCORS) and has been a member of the Sewage Sludge Subcommittee of ISCORS for the last seven years. He also recently served as Chairman of the International Atomic Energy Agency Technical Meeting on regulatory approaches for the control of environmental residues containing naturally occurring radioactive material. He has held positions with the National Academy of Sciences, Congress' Government Accountability Agency, USGS and the State of Massachusetts. So, with that, Loren will be talking about worker safety issues.

Loren: Thank you very much, Andrea. Because radiation is invisible, tasteless and odorless, it is commonly overlooked as a potential hazard at water systems. Radiation exposure can present serious health hazards. Systems need to determine whether a radiation problem exists and if it does, take appropriate safety precautions to prevent or limit water systems' staff members' exposure to radiation.

A system should contact a professional radiation protection specialist or health physicist for assistance in conducting a radiation survey if: 1) the system has had an analytical result within the last five years that has approached or exceeded an MCL for regulated radionuclide; or, 2) if calculations derived from use of the EPA's SPARC program indicates potential concentrations of radioactivity in residuals and filters in the system. A radiation survey can be conducted by using a radiation survey meter to identify any points at which contamination exists,

using an integrating radiation measuring device to determine whether exposure could occur over time or sampling filter media wastes and water through further laboratory analysis. Some states require radiation protection specialists or health physicists who conduct radiation surveys, including radon surveys, to be certified or licensed.

Although designed for post cleanup surveys of radioactively contaminated sites, EPA's multiagency radiation survey and site investigation manual or MARSSIM provides useful information on planning and conducting a survey of potentially contaminated surface soils and building surfaces. The manual and other information on radiation surveys can be obtained from EPA's radiation protection division website, www.epa.gov/radiation and then MARSSIM. We've heard some of this earlier, but water system workers are most likely to be exposed to elevated levels of radioactive materials when coming into contact with residuals, filter backwash and sludge, carrying maintenance of contaminated pumps or piping or while moving or transporting wastes and filters for disposal.

Possible sources of radiation include pumps and piping where mineral scales accumulate; lagoons; flocculation and sedimentation tanks where residual sludges accumulate; membranes and resin filters pumping stations and storage tanks where scales and sludges accumulate; and facilities where filter backwash, brines or other contaminated water accumulates. Facilities that are enclosed present the potential for enhanced radiation inhalation exposure, particularly from radon. Exposure to radon can also occur at residuals processing or handling areas at the system and offsite locations such as landfills where residuals are shoveled, transported, or disposed of.

The three primary paths of radiation exposure at a system are inhalation, ingestion, and direct exposure. Inhalation of alpha or beta emitting radioactive materials is a concern because radioactive materials taken into the body results in radiation doses to internal organs and tissues such as lining of the lungs. Workers could inhale radioactively contaminated dust or water droplets while dealing with residuals or during normal filter operations like air scour, high pressure water sprays, and backwash operations. Ingestions, or the swallowing of alpha, beta, or gamma emitting radioactive materials is a concern for the same reasons as inhalation exposures. Workers can ingest radioactive materials if they fail to observe good sanitary practices, including washing their hands before eating, failing to cover their noses and mouths by wearing approved respiratory protection, and swallowing contaminated dust and water droplets or eating and drinking in areas where dust and water droplets could settle on food or drink. Radioactive materials that emit gamma radiation are a direct radiation concern because the gamma rays pose an external radiation exposure hazard. Because gamma rays can pass through common construction materials and most protective clothing, the distance between the radioactive material and the person, as well as the time spent in proximity to the material are factors in the amount of exposure the person receives.

The Occupational Safety and Health Administration (OSHA) has developed occupational radiation standards. Those can be found in regulations at 29 CFR 1910.1096. These apply whenever an operator becomes aware of the presence of radiation at the facility, that's the trigger. Although these standards may not apply to municipal water treatment plant workers, these workers may be covered by the state OSHA programs requiring that all controls, monitoring, record keeping, and training outlined in the OSHA standards be met.

OSHA standards that may be applicable to water systems include requirements that personal protection equipment (PPE) for the eyes, face, head, and extremities, such as protective clothing, respiratory devices, and protective shields and barriers be provided, used, and maintained whenever processes or radiological hazards capable of causing injury for absorption, inhalation, or physical contact necessitates such equipment. There are numerous other requirements related to the possession and use of PPE, including training for employees who would use the equipment. This can be found in the regulations at 29 CFR and 1910 Sections 132-136. Requirements for practices and procedures to protect employees in general industry from the hazards of entry into permit-required confined spaces and needs to be set up as well and there's special discussions about that in 29 CFR 1910.146.

In addition to the OSHA requirements, systems should be encouraged to follow the safety practices described next. These measures can reduce workers at risk of exposure to radioactivity and radioactive particulates. Use an OSHA approved respirator to avoid inhalation of biological pathogens and chemically toxic materials and residuals. Simple dust masks may not provide adequate protection. Limit time spent at land disposal sites, ventilate all buildings, especially where waste with high concentrations of radium is stored and take standard OSHA measures to limit potential ingestion of heavy metals and biological pathogens present in filters, sludges, and then all disposal sites to reduce possible ingestion and exposure to radioactive materials.

Use protective gloves and frequently wash hands to reduce the potential for ingestion. Similarly, avoid eating and drinking in the vicinity of facilities or land disposal sites. Locate treatment units and waste storage area as far away from common areas such as office as possible. And shower after exposure to potentially radioactive materials. Also, launder work clothing at the system if possible.

If laundering equipment is not available, workers should keep and wash work clothing separately and avoid wearing contaminated clothing into the home. Work boots and shoes should be wiped and cleaned after potential contamination. They should stay at the system or not be worn into the home. Use gamma survey instruments or monitors at least once annually to monitor the system's ambient radiation levels in areas where radionuclides are removed.

Monitor levels of radiation to which staff are exposed. Systems should contact or be referred to state or other radiation experts for more information on how to monitor radiation levels. If radionuclides or radiation had been found in drinking water or at a system, having operators who are trained in treating for radionuclides, handling, disposing of, and transporting waste is highly recommended. Operators should also be trained in how to measure radioactivity levels. Systems should check with their state to determine whether classes are available.

Radon is a natural decay product of radium and other radium nuclides. It's therefore appropriate for systems to consider radon protection measures when handling waste containing radon. EPA recommends that water systems should check for the presence of radon in buildings and casing system equipment and that action should be taken to reduce radon levels where testing shows average concentrations of 4 picocuries per liter or greater.

OK. And here's some information, who to contact, assistance and advice are available from appropriate state radiation control programs, the Conference of Radiation Control Program Directors (crw.crcpd.org), and the EPA Regional Radiation Programs and we have a contact at the EPA Radiation TENORM site. It's called keyradcontacts.htm. OK. And that's it.

Andrea: Great, thanks, Loren. Looks like we had a question that came in. "Do we have any evidence that exposures are significant at water treatment plants?"

Loren: Well, at this point, we don't, but we do know that the levels of radiation associated with, particularly some of the resin filters, are extremely high. We've seen numbers as high as 40,000 picocuries per gram for radium. Those kind of exposure levels for any prolonged period might be potentially harmful and so it's going to be up to the systems once they know that they have radiation potential issues and accumulations to begin to do a survey to determine if they may have possible problems.

Andrea: Thank you. Looks like we have about eight minutes or so for questions. There were a few questions that came in from Nebraska on point-of-use and the first one, "does the EPA know of any point-of-use devices that are certified for the removal of uranium?" The last time I checked that, I was unable to find any point-of-use devices that had been certified by NSF or NIST for the removal of uranium. And that's true right now. There aren't any NSF standards right now for point-of-use for uranium and that is something that our staff is looking at to see if that's something that we could push NSF a little bit more in trying to get a standard for uranium for point-of-use. Another question was, "what frequency of testing, both initial and routine is recommended for point-of-use devices?" That's something we have a draft guidance document right now for point-of-use and in there, it doesn't go into that much detail either in terms of the frequency of testing. I know we get a lot of questions about that, if you're going to use point-of-use, how frequent should you be testing your waters, sampling your waters? And that's something right now that may be left up to the state, but there are definitely questions about that and in terms of the implementation guidance right now, it's out for review and they're hoping to have it finalized sometime this fall.

Another question that came from that is, "what is the maximum number of connections for a point-of-use device to be economically feasible?" And that, again, kind of depends really on the technology that you're going to be using, but probably on average, maybe 20-100 households. We find it economically feasible and part of it is just going over 100 people, is that costs are increasing with the maintenance of the point-of-use devices, so that's kind of where your costs are going up. I think that's it. Are there any other questions? I know we had some questions in terms of treatment technologies. Dennis, were you able to see any of those during the Web cast?

I think there was a UIC question that said, "what is the definition of hazardous or radioactive?"

Bruce: This is Bruce. I was able to just jump out and do a little bit of research. There were actually two questions. One was, "how do PWS systems overcome the high cost of Class I wells?" That's actually a good question. I mean typically these Class I wells can cost upwards

of a million dollars and so I don't want to scare anyone away from it, but yeah the cost of permitting and construction is pretty high. I think one thing that we should make it clear is that you just can't go to any Class I well. Pretty much you have to go to a Class I well that's a commercial facility that's willing to take these type of waste streams and just don't go looking to like a neighboring facility and expect that they will take that waste either.

Someone also asked the question, "what do you use for determining whether it's hazardous or radioactive?" Well, as far as the hazardous question goes, we're no different from RCRA. You can go to your 40 CFR, Part 261 and look at what the levels are. For example, if it fails TCLP, what are the levels that will make it a toxic waste and, therefore, a hazardous waste, they're listed in there. For example, arsenic 5 mg per liter. Also, if it's an ignitable waste or it's a corrosive waste if your pH is less than 2 or greater than 12.5, that may cause it to be a hazardous waste and if it's a reactive waste, I don't know what the characteristics are of these drinking water residuals. If whether or not they're ignitable or reactive, but that could make it a hazardous waste as well and I think we've put down the information about what we consider in the UIC program makes it a radioactive waste, so I just won't go into that anymore.

Dennis: Andrea, this is Dennis. I tried to answer that question, but my microphone was muted and pushed the off button and had to get reconnected. There was one question that said "about barium sulfate, why is this not used?" I really don't know of any. I spent some time visiting a plant in Saudi Arabia that has a barium sulfate system and they actually preferred it for radium removal to manganese oxides because the manganese oxides were black and they were showing up everywhere in the plant. One of the issues that came up just a few minutes ago was radiation safety. One of these precipitating things like manganese and barium will make a pipe scale and that pipe scale will generate a lot of alpha activity due to the radium, lead 210, and there's some gamma activity that comes off and through the pipe and so that may be one reason barium sulfate is not used, but I don't know any reason, not costwise, I think its cost is reasonable, and the fact that it's a white precipitate rather than a black scale, that would stain fixtures and things in the system is probably an advantage.

Another question was, "do we have arsenic and uranium removal problems together, as co-contaminants?" I don't, never have worked with any directly, but ion exchange will work. If you're removing arsenic, you're also removing uranium and when you regenerate the resin, you will regenerate the uranium off, so it's not a problem. If there's arsenic in the water, arsenic can be removed by ion exchange and uranium will be removed at the same time. The issue that I did run across is perchlorate contamination with uranium and in that case, the perchlorate runs for a very long time in those situations, they may run for a hundred or tens of thousands of bed volumes and, in that case the uranium that builds up on the resin may be a problem. In fact, it's been suggested that those columns be regenerated just to remove the uranium and while not actually removing much of the perchlorate. Those are the only questions that I remember seeing.

Andrea: Great, thanks Dennis. We do definitely have some other questions out there, it looks like we're just about out of time here, so, as I said before, we'll do it like we did for the last Web cast. We'll have a question and answer log that we will answer and post onto our web site. Again, it's going to take some time, there's a lot of good questions out there and it takes some time for us to answer, so we really do appreciate your patience in waiting for these

questions and answers to come out. We are also sending out another evaluation as we did for the last ones. We really encourage you to fill it out, it really helps us in developing our next Web casts that are coming down and speaking of Web casts, we do have our next two arsenic Web casts and they're scheduled for September 15th and October 20th. So, I hope you can all make it and also we're having some total coliform rule Web casts coming up as well, so stay tuned for those. So, with that, thank you again for participating in this Web cast. We really appreciate it and hope you got something out of it. So, I think we're finished and thank you again.

Host: That concludes today's seminar and thank you for joining us today. The slides shown in today's presentation will be posted on the EPA's website in the very near future. Have a great day.

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